

33. ✓ c) regression

a)

x	y
0	297.3
5	272.1

306.4  
250

$$\frac{250 - 306.4}{5 - 0} = -11.4$$

-11.4 bill \$  
yr

f) reg  
How fast at 2003

X	Y
12.9	13
13	13.1

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### 2.4b Instantaneous Rate of Change

Estimate the instantaneous velocity at  $t=1$

rhbg =  $\frac{16-1}{4-1} = \frac{15}{3} = 5$

$\lim_{\Delta x \rightarrow 0} \frac{\Delta y}{\Delta x} \stackrel{?}{=} 2$

Same (mst. velocity = 2)  
slope of tangent line = 2

The graph shows the function  $f(x) = x^2$  on a coordinate plane. A secant line passes through points  $(1, 1)$  and  $(4, 16)$ , with a slope of 5. A tangent line is drawn at the point  $(1, 1)$ , with a slope of 2. The x-axis is labeled 'time' and the y-axis is labeled 'position'.

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Find the exact instantaneous velocity at  $t=1$

$\lim_{h \rightarrow 0} \frac{f(1+h) - f(1)}{h}$

$\lim_{h \rightarrow 0} \frac{(1+h)^2 - 1}{h}$

$\lim_{h \rightarrow 0} \frac{1 + 2h + h^2 - 1}{h}$

$\lim_{h \rightarrow 0} \frac{2h + h^2}{h} = \lim_{h \rightarrow 0} 2 + h = 2$

The graph shows the function  $f(x) = x^2$  on a coordinate plane. A secant line passes through points  $(1, 1)$  and  $(1+h, (1+h)^2)$ . A tangent line is drawn at the point  $(1, 1)$ . The x-axis is labeled 'h = Δx'.

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$\lim_{h \rightarrow 0} \frac{f(a+h) - f(a)}{h}$

mst. velocity at  $x=a$   
slope of tan line at  $x=a$

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Example 3 Find the equation of the tangent to the parabola  $y=x^2$  at  $x=2$

$$\begin{aligned}
 f(x) &= y = x^2 \\
 \lim_{h \rightarrow 0} \frac{f(2+h) - f(2)}{h} &= \lim_{h \rightarrow 0} \frac{(2+h)^2 - 2^2}{h} \\
 &= \lim_{h \rightarrow 0} \frac{\cancel{4} + 4h + h^2 - \cancel{4}}{h} = \lim_{h \rightarrow 0} \frac{\cancel{h}(4+h)}{\cancel{h}} \\
 &= \lim_{h \rightarrow 0} 4+h = 4 = m_{\text{tan}} \\
 \text{tan line: } y &= 4(x-2) + 4 \quad x=2 \quad y=4
 \end{aligned}$$

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Example 5 Find an equation for the normal to the curve  $y=4-x^2$  at  $x=1$

$$\begin{aligned}
 &\perp \text{ to tan } y=4-x^2 \\
 m_{\perp} &= -\frac{1}{m_{\text{tan}}} \\
 m_{\text{tan}} &= \lim_{h \rightarrow 0} \frac{f(1+h) - f(1)}{h} \\
 \lim_{h \rightarrow 0} \frac{4 - (\cancel{1}+h)^2 - 3}{h} &= \lim_{h \rightarrow 0} \frac{4 - (1+2h+h^2) - 3}{h} \\
 \lim_{h \rightarrow 0} \frac{\cancel{4} - \cancel{1} - 2h - h^2 - \cancel{3}}{h} &= \lim_{h \rightarrow 0} \frac{\cancel{h}(-2-h)}{\cancel{h}} = - \\
 m_{\text{tan}} &= -2 \quad m_{\perp} = \frac{1}{2} \quad \text{point } (1, 3) \\
 \text{normal: } y &= \frac{1}{2}(x-1) + 3
 \end{aligned}$$

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Example 6 Find the speed of a falling rock at  $t=1$  if the distance it falls is  $y=16t^2$

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